Reply to Reviewer:

Given the importance of the finding on the relative predictability of the blocked and zonal regimes, I would suggest giving a bit of history on it. Overall, the review on low-frequency variability (LFV) of the midlatitude atmosphere in the paper's introduction is quite careful and complete. But the authors might wish to emphasize the fact that Legras & Ghil (JAS, 1985) were the first to find the greater stability and hence predictability of zonal flows in their 25-variable barotropic model on the sphere. This result was followed in the experimental paper of Weeks et al. (Science, 1997), using a barotropic rotating annulus, by a study of the variability and persistence of the laboratory blocked flow that essentially confirmed the findings of Legras & Ghil (1985); see especially Fig. 5 in Weeks et al. (1997). So did the Lucarini & Gritsun (Dyn., 2020) paper, which used the three-layer quasi-geostrophic model of Marshall & Molteni (JAS, 1993) and the methodology of unstable periodic orbits (UPOs). The fact that Lucarini & Gritsun (2020) used a baroclinic model removes the doubts about the greater stability of zonal flows being exclusively due to the barotropic character of the Legras & Ghil (1985) model and of the Weeks et al. (1997) apparatus.

Thank you very much for the suggestion. As per the comment we included a more elaborated introduction including all the mentioned literatures in the revised version of the manuscript from lines 105 to 120. The included portion is

"Legras & Ghil (JAS, 1985) employed a higher-order barotropic spectral spherical model to investigate blocking and zonal flow regimes dynamics, suggesting that their model displayed properties akin to an index cycle, and later stochastic forcing was introduced to Charney's deterministic model, leading to transitions between high- and low-index states (Benzi et al., 1984; Egger, 1981; Sura, 2002). The impact of stochastic forcing on the stability of atmospheric regimes was also recently considered in a highly-truncated barotropic model by Dorrington and Palmer (2023), where they provide a mechanism to explain the increased persistence of blocking due to the noise in such simple models.

In this paper, Legras and Ghil (1985) also discussed the realistic existence of blocked and zonal flow regimes which are obtained as unstable stationary solutions due to the barotropic influence of the LFVs in the atmosphere. More persistent zonal flows are also identified in several occasions which seems to be a deviation from the earlier studies. Later the stability studies by Weeks et al. (1997) recreating zonal and blocked regimes in an experimental annulus setup further substantiated the findings of Legras and Ghil (1985).

Schubert and Lucarini (2016)'s numerical investigation employing a QG model revealed a counter-intuitive finding that during blocking events, the global growth rates of the fastest growing covariant Lyapunov vectors (CLVs) are significantly higher, indicating stronger instability compared to typical zonal conditions. The difficulty in predicting the specific timing of blocking onset and decay further contributes to the observed instability behavior, aligning with Kwasniok (2019) findings associating anomalously high values of finite time largest Lyapunov exponents with blocked atmospheric flows.

Lucarini and Gritsun (2020) demonstrated that blocking phenomena exhibit higher instability compared to typical atmospheric conditions, irrespective of whether they occur in the Atlantic, Pacific, or globally. This analysis utilized the simplified atmospheric model proposed by Marshall and Molteni (1993) and assessed stability based on unstable periodic orbits (UPOs). Importantly, this research dispelled the misconception that the increased stability of zonal flows solely resulted from the barotropic nature of the model in the study of Legras and Ghil (1985) and Weeks et al. (1997) apparatus. Consistent results were obtained by Faranda et al. (2016, 2017), utilizing extreme value theory for dynamical systems, which identified blocking regimes with unstable fixed points in a heavily reduced phase space. Their findings indicated that blockings exhibit higher instability in the circulation, linked to an increased effective dimensionality of the system. This agreement with Lucarini and Gritsun (2020) study further supports the notion that blocking events display stronger turbulence and instability, challenging conventional expectations."

It would be of particular interest if the authors of the present paper could take a closer look at baroclinic vs. barotropic effects in their model, with respect to this question of the relative stability and persistence of blocked vs. zonal flows, when the two types of regimes coexist. See also the discussion in Ghil & Lucarini (Rev. Mod. Phys., 2020, p. 035002-36).

This is an interesting comment. Indeed it is really important to analyze the stability of flow regimes that were influenced by the barotropic or baroclinic part of the model. In the discussion of Ghill & Lucarini (2020), they were pointing out 4 different possibilities to obtain an unstable blocking event compared to the zonal flow which includes slowing down of Rossby waves or their linear interference, the existence of multiple flow equilibria resulting slower flow regimes, the idea of oscillatory instabilities of one or more of the multiple fixed points that can play the role of regime centroids and the last one was the formation of blocking events when the trajectory is near an extremely unstable periodic orbits (UPOs). As this comment says, instability could also be because of the barotropic or baroclinic part of the model. Inorder to find out that, we tried to average the barotropic and baroclinic stream function with respect to each cluster to identify the existence of different stream function values between zonal and blocking representing clusters and also studied the distribution of each baroclinic and barotropic mode But the results are inconclusive which denotes that it needs a more extensive methodology which we will pursue in our future works.

The authors refer to using a "machine learning algorithm called Gaussian Mixture Clustering (GMC)," which is described in Appendix A. While machine learning and AI are all the rage these days, I'd be curious to know how this algorithm differs from the one that was used on observational data by Smyth et al. (JAS, 1999).

We were really sorry to use the term 'Machine learning' since it is more of a data driven algorithm which we were corrected in the revised manuscript. Apparently the idea is the same as that in the paper Smyth et al., 1999.